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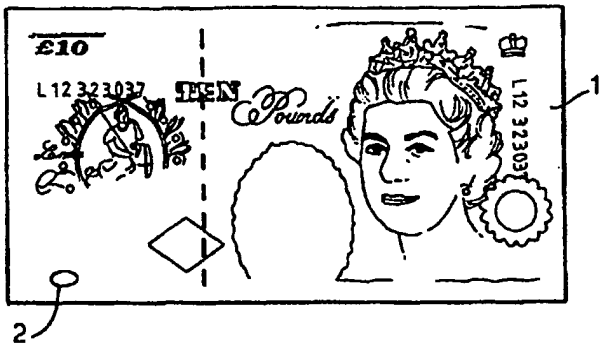

(57) Abstract

A document (1) carries indicia and at least one copy protection device (2). The copy protection device (2) comprises a marking separate from the indicia and defined by a pair of inks (3; 4-8) which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning. When the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

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PREVENTING UNAUTHORIZED COPYING OF DOCUMENTS

This invention relates to documents such as security documents and the like, and in particular to a copy protection device for preventing the copying, for example counterfeiting, of coloured security printed documents, in particular bank notes and monetary tokens, by copying on a colour copier or the like.

This invention will be described principally with reference to the colour laser copier prevention although the methodology has applicability to preventing other forms of electronic scanning and printing as will be described.

The term "counterfeiting" in this specification relates to the unauthorised attempted manufacture of replicas of genuine documents with a view to passing the replicas as genuine.

Colour laser copiers are becoming increasingly common. As that happens the opportunities for their misuse by criminals in their counterfeiting activities also increases. Despite the many security features in a bank note which a colour copier is incapable of reproducing and the generally erratic image quality which occurs on colour laser copier replication which leads to counterfeits being detected quickly, there is nevertheless the need to prevent even poor quality copies of paper monetary tokens and other security documents being made.

Colour laser copiers operate by electronically scanning a document and forming digital bit maps of its continuous tone colour image, in the primary colours of red, green and blue. This colour separated data is generally electronically converted under software control to matched subtractive data colour sets. A replica is then printed made by the secondary colour data controlled deposition of yellow, magenta, cyan and sometimes black media. In the colour laser office copier this replica print is generated by the placement of subtractively coloured xerographic toners. For prepress proofing

application subtractively coloured wet toners may be employed.

The primary to secondary colour conversion software usually also provides for the replica image to have a halftone dot structure, so as to simulate the continuous tone colour gradations in the original document. Although under magnification the replica can be seen to be quite different from the continuous tone colour original, at the normal viewing distance the eye will often perceive the copy to be a passible facsimile of the original. This is naturally undesirable for security printed items as replicas may be used to defraud.

Generally a device which comprises a colour separation scanner for documents and which prints replicas of the scanned document in the subtractively coloured toners and optionally additionally black toner through the action of a laser operating under control of the data sets which exposes an electrostatically charged photoconductor is termed a "colour laser copier". Such copiers are made and widely sold by Canon KK.

More recently in the desk-top publishing market low cost colour scanners and colour printers have become available and these are generally employed with a personal computer to provide a simple means of producing a colour print.

It is also desirable to be able to prevent commercial colour scanners from forming data sets which may be used to form black and white colour separation negatives for use in making plates for offset lithographic printing presses and the like.

EP-A-0083062 describes a method and apparatus for detecting counterfeit documents after they have been copied. This involves irradiating a document with wavelengths outside the visible range and monitoring the response of the document. The specification indicates that inks used in colour copiers have a different response from printing inks and this can be detected thus indicating,

when detected, that the document is a copy rather than an original. The drawback of this approach is that the copied document is already produced and the system can only provide belated confirmation that it is a copy.

Other conventional approaches to this problem involve creating original documents with complex indicia such as patterns and graphics which defeat the resolution and accuracy of a colour copier. An example of this approach is described in GB-A-1534403. This document goes further in describing the use of ink pairs which are identical in visual colour but which have different infrared absorbences. By printing the inks side by side the eye does not see any difference in colour from one ink to the other but a difference in infrared response can be discerned using infrared viewing means. The ink pairs can be placed as bar codes or geometric shapes. Infrared differentiation may be undertaken by machine reading methods. Again, this relies on the ability to examine a document after it has been created to determine whether or not it is genuine. Furthermore, it requires a complex printing system to print the visible patterns in the ink pairs.

There is thus a need to prevent the counterfeiting of documents by such generally available colour replication methods, even though the reproduction quality of such electronic printers may be poor.

It is known that security documents can be authenticated by sensing the presence of individual attributes such as the presence of a metallic thread or a magnetic ink. Such methods are often used during used bank note sorting. While it may be possible to design a specific machine to detect a single type of document there is a need for a colour copy prevention method which can be applied to a wide range of documents such as travellers cheques, vouchers, credit notes and bank notes which may pass from one country to another for counterfeiting without forcing complete redesign of the documents. Thus there is

a need for a simple, secure, fast, cost effective, discrete method of general applicability.

US-A-4603970 describes a method of inhibiting the copying of confidential documents by treating the documents beforehand with an infrared ray absorbing agent. On establishing the absorbence to be above a reference level copying is stopped. This method would however appear to prevent the copying of a proportion of genuine documents which happen to have an infrared absorbing material present on their surface such as carbon black pigment in an ink or toner formulation. On a practical level heavily used documents such as banknotes can become soiled and so become infrared absorptive. There is a need to be able to distinguish new or soiled genuine notes from new or soiled counterfeits.

EP-A-0594445 and EP-A-0595583 published on 27 April and 4 May 1994 respectively (after the priority date of the present application) disclose copying apparatus which detects patterns on documents to inhibit the copying process. Specifically, infrared absorbing marks are provided on documents in particular patterns which can then be detected. There are a number of problems with this approach. For example, certain conventional printing inks have infrared absorbing properties and the presence of these inks may inadvertently result in a pattern which indicates that copying should not take place. Furthermore, the underlying pattern on the document may affect the appearance of the marking.

EP-A-0493961 (US 5,225,900) describes the use of a taggant on a document to prevent unauthorised reproduction. The taggant is typically in the form of an additive to the inks or dyes used to print indicia on the document and again suffers from the problem outlined above concerning soiling.

Other colour laser copy preventers have used the whole document and visible pattern recognition techniques. In these cases, the complete document image or a substantial

portion is recorded and stored as bit maps for a given scanned colour. The colour bit maps, or an equivalent black and white image bit map, may be used for comparison with a set of genuine document data sets stored within the memory of the colour copier's computer. If the sample data set matches a reference data set then the colour laser copying action will cease.

While in theory this approach is attractive for identifying single documents, it would require a formidable amount of graphical bit map reference memory to allow a wide range of documents to be stored. This is also likely to increase the scrutiny time and as most of the documents to be colour copied will be non-valuable documents a delay of even a few seconds is likely to be commercially unacceptable.

The prior art matching methods have also to take account of the orientation of the document and this is likely to require excessive computational capacity and time. Such an approach is unsuitable for the simpler, desk-top types of scanning.

Although colour laser copiers may be provided with large memories to allow the holding of colour separation bit maps of whole documents, which are then processed and sequentially printed, there are newer printing methods in which small areas of documents are scanned in colour separation fashion: here printing of the document occurs generally simultaneously although with a short lag. In other words, the printing of the replica has started before the scanning of the document is completed.

Here the document is copied as a sequence of small, generally rectangular, adjacent blocks. In such a case an ink jet printer can be used to print out quickly the facsimile, in subtractively coloured inks. This replication copying method is relatively rapid and does not require enormous computer processing power. Each area is scanned and printed on its own.

Such developments impede the use of "whole document" image pattern recognition methods as these have databases which must hold reference images of a wide range of documents.

Despite the considerable benefits of the prior art image matching methods which have found application in certain circumstances, it is important to find new, improved, simpler and practical ways of automatically stopping colour laser copy replication of wide range of documents, in a manner which will not inconvenience lawful users.

In accordance with one aspect of the present invention, we provide a document carrying indicia and at least one copy protection device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

In accordance with a second aspect of the present invention, a method of copy protecting a document carrying indicia comprises applying to the document at least one marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of

this combination of properties indicates that a copying process should not be carried out.

In accordance with a third aspect of the present invention, a method of copying a document comprises scanning the document under visible light to generate digital data defining one or more colour separations which together define the appearance of the document; and generating a copy of the document by controlling output means in accordance with the digital data and is characterised by additionally scanning the document under at least one wavelength outside the visible wavelength range; monitoring the response of the document when scanned at said at least one wavelength and comparing the monitored response with one or more predetermined responses; and preventing the generation of a copy of the document if the result of the comparison indicates the presence of one or a predetermined number of copy protection devices, the or each device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

In accordance with a fourth aspect of the present invention, apparatus for copying a document comprises scanning means for scanning a document under visible light to generate digital data defining one or more colour separations representing the appearance of the document; and output means for generating a copy of the document in accordance with the digital data and is characterised by control means for causing a document to be copied to be

illuminated under at least one wavelength outside the visible wavelength range; and detection means for detecting the response of the document to said illumination, the control means being responsive to the detection means to prevent the output means from generating a copy of the document if the detected response indicates the presence of one or a predetermined number of copy protection devices, the or each device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

The invention provides a copy protection device which is generally invisible to the naked eye and is a self-contained marking not forming part of the normal, visible indicia of the document. Furthermore, by providing the marking using at least a pair of inks, the marking is wholly positively defined and does not rely on properties of the underlying document or inks and so avoids the problems of the markings described in EP-A-0594445.

The apparatus for copying a document can have a conventional construction as described for example in EP-A-0594445 and US-A-5225900 but suitably programmed to detect the particular copy protection device(s) specified. Typically, the control means includes a store for storing data defining the appearance of the or each copy protection device, and means for comparing information from the detection means with the stored patterns to determine whether the protected response corresponds to the or one of the stored patterns.

The requirement that the pair of inks presents a continuous, substantially plain coloured area when viewed and illuminated under visible light is fulfilled ideally if no visible pattern can be detected. In other words, the variation in the device is hidden. Generally, even the existence of any marking is not discernable to the naked eye. This can be achieved if the marking has a visible colour substantially the same as the underlying colour in which it is printed. However, it is possible that there may be minor fluctuations in hue and density and the term "substantially" is intended to cover these tolerances.

The requirement that the different inks are also substantially undetectable when the area is subjected to visible colour separation should be judged in a similar way. Scanning is ideally fulfilled when no pattern can be detected within each colour separation but the term "substantially" is intended to indicate that there may be some small fluctuations in hue which may occur particularly when the device is printed.

Typically, the presence of the different inks is substantially undetectable when the area is subjected to red, green and blue colour separation scanning.

The following are formulae of two lithographic inks which are substantially similar in their visible colours but which have different infrared absorbance properties. All parts are by weight.

Ink 1 (IR Absorbing Ink)
Heliogen blue D7080 (BASF) 15.25
Printex 55 (Degussa) 1.25
Lithographic alkyd resin
ink vehicle 83.50

Ink 2 (excluding infrared absorber)
Heliogen blue D7080 (BASF) 14.10
Paliogen black L 0084 4.75
Blue D 28329 (Chas. Tennant Co.) 1.15

Lithographic alkyd resin
ink vehicle 80.00

The inks may be lithographically printed in close register to form alternately equally spaced bands of Ink 2 against the other and on visible inspection the two colour matched inks will not be readily distinguishable. Their R,G and B responses will be substantially identical in that no distinction between the inks is discerned but on near infrared illumination the scanner will be able to create a digital representation of the pattern of Ink 1 on a background of Ink 2, which can be compared with a reference pattern held in a database.

The invisible attribute or pattern which is exhibited may be an absorbance or luminescence which occurs at an invisible wavelength, such as in the near-ultraviolet or in the near-infrared. Alternatively it may be a luminescence which occurs in the visible spectrum caused by near ultraviolet or near infrared illumination, or a luminescence in the near ultraviolet or near-infrared caused by ultraviolet, visible or infrared illumination. It is preferred to reveal the pattern under non-visible illumination.

The apparatus may detect the presence or absence of infrared or ultraviolet absorption and so generate a corresponding linear or two dimensional bit map. Alternatively on near infrared or near ultraviolet illumination the special ink or inks may fluoresce or phosphoresce and the luminescence may be used to may be detected to form the invisible image bit map.

Typically, one ink will include the scanner detectable material for generating the pattern although in some cases both inks could provide this but with different characteristics (e.g. degrees of absorbency). In the former case, the colour of the first ink formulation is matched by the second ink formulation which includes the scanner detectable material. Such scanner detectable

materials, for example infrared absorbing inks, may be slightly coloured.

In the preferred embodiment an infrared absorbing ink may be used as the second ink. During verification scanning the scanner would scan for example in the near infrared.

The local infrared pattern would be detected, stored in a sample data set and matched with the sample pattern data sets held in the store. On matching, the colour copying replication action would terminate and possibly a warning would be sounded.

As an alternative to infra red absorbing inks, an invisible ultraviolet responsive visible light luminescing agent may be employed within the second ink, the first ink not being fluorescent on ultraviolet illumination. In this case the document would be illuminated by an ultraviolet source in darkness and a bandpass filter covering the sensing (eg contact linear image sensor or CCD image) array would be employed only to allow the recording of the luminescent pattern. By comparison of the stored luminescent pattern with the sample the colour replication printing of predetermined document having the feature could be stopped, yet documents which merely exhibited general luminescence at the wavelength or luminescence at other wavelengths could still legitimately be copied.

The devices of the invention are intentionally small in size, typically being less than $2mm^2$, possibly less than $0.75mm^2$ or even less than $0.2mm^2$ in combined area. They are thus in practice unnoticeable and have the advantage that they may readily be integrated with existing security document designs, including those which are very well known in printed currency and the like, without forcing a significant redesign.

The invisible pattern will generally be a simple geometric shape such as a parallel line set, a triangle, square, rectangle, elongate rectangle, pentagon, hexagon, or other regular or irregular polygon, a circle or an

ellipse. For example the pattern may be of a solid shape of one of the above. Alternatively there may be a more complex pattern.

Alternatively there may be a combination for example a small circle surrounded by spaced substantially identically sized circles, these surrounding circles depicting a hexagon.

As the invisible attribute scanner passes across the device during a linear stepped scanning mode a digital data sequence will be formed.

Thus a data set will be formed of the invisible (e.g. infrared absorbing) image. For example a linearly sampled data set across the centre of a square area of infrared absorbing ink would broadly indicate "no image/ image/ no image". This data set taking also into account the number of pixels involved and hence the size of the device would then be matched to a corresponding data set stored in the memory. On correlation the system would regard the document as copy protected and cease the copying action.

Two dimensional pattern matching methods may be used as an alternative to linear transition tracking.

A number of such devices may be provided in a document for example two, three, four, five, six, up to ten, or more. In a preferred embodiment one or more devices will be provided at the margins i.e. in the vicinity of the edges of the documents, more preferably at least one at each margin so that copying can be stopped as soon as possible. If a plurality of devices are provided on a copy protected document, these need not all have the same visible colour or pattern although in each device the two inks will need to be in matched pairs or produce the same visual and scanner respective effects as a matched pair.

In addition or as an alternative to the devices being presented at the margins of the document they may be incorporated in the central areas.

It is desirable to provide a plurality of such devices on any one document and to make the devices small so as to

make a counterfeiter's effort more difficult. The use of small areas for the device allows the more facile integration of the devices into previously designed security documents, thereby avoiding the need for a major redesign of the document. Small areas with simple patterns are possibly also faster to assess in terms of the computational effort required.

Thus in the alternative method, a document exhibiting a plurality of copy prevention devices on its surface is first scanned for the presence of a first copy prevention device. The sampled infrared and visible light data is used to create a scanning score. This is then matched to determine the degree of compliance of the visual and infrared data or derived data with predetermined acceptance and rejection threshold parameters held by the control means in the form of a data set.

In one aspect if the degree of compliance or score (e.g. a percentage match as known from conventional pattern matching algorithms) is above the threshold the copy prevention or other related means may be immediately activated. If the sample score falls into a lower band, the score for a determination on a second device can be sought and then a derived score can be created. This in turn can be used for assessment against predetermined thresholds for the derived set. For example, the scores for two samples each of which just fails to stop copying on its own could be added together and the total being above a threshold could then be used to cause deactivation.

A greater number of areas may be determined and the cumulative sum or a derived score may then be used to determine whether the copy prevention means should be activated.

This method of scoring is useful for soiled or mildly damaged documents as it is undesirable to allow copying of a value document in which for some reason the score from the first assessed copy prevention device is not sufficient to warrant activation of the copy prevention means.

By using a plurality of determinations which may also take into account factors relating to the position of the features on the document or unrelated sensed attributes such as the presence or absence of fluorescence, a higher level of confidence can be automatically made for acceptance or rejection.

This methodology is likely to reduce the number of false rejections and false acceptances, maximise the true acceptances and true rejections and improve the statistical reliability of the system.

Various methodologies of computing the confidence score can be employed as known in the art.

The copy prevention means may also take into account the presence or absence of other attributes of the document which can be sensed but which have quite separate electromagnetic characteristics from the copy prevention devices described previously in the patent application.

In addition to providing discrete devices, it is possible for areas within a document design to be adapted so that a counterfeit copy preventing pattern can be formed. Here the anti-copy device would be integrated into other design elements rather than being isolated.

Thus a pictorial or other design could comprise two narrow convex bands of ink which are of similar width and which face but which do not quite come into tangential contact being separated by a distance similar to the width of one of the narrow convex bands at their point of closest approach. These bands could be depicted by a first coloured ink which would absorb infrared radiation.

Between the first bands may be printed a further coloured band of the same colour. The width of this band would be such that a continuously coloured anti-counterfeit device area would be provided. The second band type would have the same colour as the first bands but not be infrared absorbing. Thus the bands where they coincide can form an area which has counterfeit copying prevention capability in accordance with the invention.

In this instance the invisible pattern would be in the form of a simple area bar code of in sequence IR absorbing ink, non IR absorbing ink and IR absorbing ink. This is the simplest form of an anti-copy design and in practice it is likely that somewhat more complicated binary designs will be made employing the principle.

In another example, if a solid circle of one colour was surrounded by smaller identically coloured circles which approached but did not touch it for example in an hexagonal arrangement, a plurality of anti-copy devices could be presented by providing further circles of the same colour which created continuously coloured areas between the central solid circle and each of the peripheral circles. This would allow the document to be protected in a variety of scanning directions.

Although the device has generally been described in the context of a matched ink pair specifically printed to form a new design element, it should be quite feasible to modify an area of plain colour which is already part of the design of an existing security document. This may be done by printing within a space left within that plain area a precisely registered infilling pattern of the second marking composition which would have the effect of satisfying the visual recognition and scanner requirements above mentioned.

By employing such simple devices, they can be employed without inconvenience to the designer, document user or scanner user. They can also be used along with other security features which may involve use of the same invisible radiation band and also function when limited soiling or creasing of the document has occurred.

Such simple, concealed patterns are difficult to duplicate exactly, and the computational time taken to assess a document which has been presented at an abnormal angle would be reduced.

The use of simple patterns, especially graphical patterns, in which the pattern is formed by the presence or

absence of the scanner detectable component enables a digital bit map to be prepared. The threshold density or absorbance for the scanner detectable element can be set within the sensing means to allow for trade variations in density. Either a linear bit map can be made from one scan line or a localised bit map array of the feature can be made.

The time taken to detect and match any pattern is relatively short in comparison to prior art whole document image matching methods which require much reference bit map data and computational capacity. Our method is advantageous in that most of the items which are colour copied will not need to be copy protected and it is important that copying of such documents can occur without undue delay. The nature of the device is such that it is unlikely to be present in everyday documents intended for copying.

The invention could typically be employed within a colour laser copier. When a genuine document identification signal was given by virtue of a copy protection device being detected the colour copier would stop scanning. Alternatively the colour copier may stop printing if it had started so that only a portion of the genuine document would be facsimiled. The electronic scanning and printing process may be started while the determination is being made simultaneously and so a portion of the document may be printed. When however the security device pattern is detected, the reproduction process is terminated. The copier may then be programmed to print a black overprint over the already printed areas, to print a warning message, to cease operation, to issue a warning sound or message, or the like.

In another embodiment, the invention could be employed with a commercial colour proofing scanner to stop the scanning and generation of high quality black and white colour separation negatives.

In another embodiment the invention could be employed with a desk-top colour scanner suitable for use with a personal computer. Such desktop scanners are generally via a personal computer to an ink jet printer. In this instance the computer would be provided with invisible pattern identification software to allow the invention to be conducted.

As it is very desirable to be able to prevent the formation of a counterfeit document rather than rely only on its being detected, the method provides a simple yet very effective approach which can be used with colour laser copiers and other forms of electronic bit mapping colour scanners. It also enables regions within document to be protected.

Although the device is preferably generated during the security printing process for the document, it could be supplied on a preprinted foil, transfer film or the like which is bonded to a document. Here the device would function as a taggant and it would allow individual documents within a series of identically designed documents to be protected. For example a personalised identity card may be copy protected at the time of issue.

It is principally intended that the printing of the device will be done on a genuine document with a matched pair of inks which have substantially identical visible colours, which are substantially indistinguishable by red, blue and green colour separation scanning but which have different infra red absorptive characteristics such that on scanning for the presence of infra red absorber an image corresponding to one of the inks will be distinguished against the other.

In a preferred mode the ink pairs will be printed by lithography.

Plain areas of printing are provided within many security documents in the form of duplex or triplex colour splits. The devices may be positioned within those areas. As ink pairs having substantially identical visible colours

are employed the existence and position of the devices is relatively concealed.

An advantage of this invention is that it does not rely merely on the existence of, say, an infra red absorbance rather it is the use of the concealed invisible pattern in miniature which is important. The miniature devices can readily be incorporated into a wide range of security documents. The devices can also be employed when other, say, infrared absorbing, materials are present on the document such as large graphical patterns of matched ink pairs as disclosed in GB-A-1534403.

The invention may be employed in colour laser copiers which scan the whole documents and then process the colour information into subtractive colour printing sets. The invention may also advantageously be employed with electronically controlled colour copying devices in which printing occurs before the scanning of the whole document is complete. Thus by incorporating the device in various portions of the document and especially close to the edges the copying process can be prevented before much of the document is printed. The invention allows each edge to be protected.

Pairs of devices may be placed adjacent to one another, each verifiable in its own right and with both images being compared in case of tampering with one device.

One device could have more than one type of invisible radiation responsive or detectable property such as one ink of the pair having infra red absorbing and ultra violet illumination luminescence properties.

In order to confuse the counterfeiter it would readily be possible to print in addition to the verification pattern a series of decoy devices, in different patterns and shapes if necessary having invisible pattern properties.

If a magnetically encoded card or other form of data card is used by the person undertaking the copying action to secure access to the copying machine the card

identification number may be recorded and stored within the controlling computer, in the event of unauthorised copying.

If the colour scanner and the colour printer are separated for example by being on geographically distant nodes of a computer network, the method of the invention may be used to inhibit the transmission of document image data from the scanner to the remote printer. Similarly the method may also be used to provide a signal which causes the recording of any scanned data of a genuine document onto a magnetic disc or tape or optical disc to be terminated and additionally a subroutine may be provided in which the portion of document data recorded is erased.

The device of the invention may readily be employed on a wide variety of secure documents such as printed currency e.g. bank notes, traveller's cheques, bank cheques, vouchers, financial tokens, tickets, passports, passbooks, licences, share certificates, bonds, letters of credit, legal documents, certificates of authenticity or regulatory compliance, brand protection labels, excise seals, identity cards, passes permits, travel tickets, entrance tickets, lottery tickets, bingo tickets, and financial transaction cards.

Some examples of documents according to the invention and apparatus for copying documents will now be described with reference to the accompanying drawings, in which:-

Figure 1 illustrates the front face of a document carrying a copy protection device and carrying indicia shown only schematically;

Figure 2 illustrates the appearance of a copy protection device under visible illumination;

Figure 3 illustrates the appearance of a copy protection device under infrared illumination;

Figure 4 illustrates a bit map corresponding to the device shown in Figure 3;

Figures 5-14 are views similar to Figure 1 but showing other arrangements of copy protection devices on documents;

Figures 15-25 illustrate different examples of copy protection devices under infrared illumination; and,

Figure 26 is a block diagram of copying apparatus.

Figure 1 shows a document 1 such as a banknote in which in a small area close to an edge is provided a copy protection device 2. It will be noted that the device 2 is positioned in an area having a substantially plain appearance and no indicia. An enlarged view of the document area exhibiting the device is shown in Figure 2 as it would be seen to the eye: the two inks forming the device have the same colour and the area appears to be plain under visible illumination conditions.

The device consists of two visible colour matched inks, printed adjacent each other (Fig 3) one ink having an invisible attribute eg infra-red absorbance which the other ink does not have, but to which the scanner is sensitive. One ink forms the background 3 and the other ink a series of regular geometric markings 4 to 8.

Thus one ink is printed to provide a series of small rectangular or square markings, 4 to 8, as shown. When the document is scanned under infrared illumination and the pattern of infrared reflectance and absorbance is recorded digitally the larger area 4 will be found to be adjacent to two smaller areas 5 and 6, and 7 and 8.

The digital bit map resulting from this is schematically depicted in Figure 4 in which the darkened areas represent a different infrared response from the undarkened ones.

The simple bit map of all areas 4 to 8 inclusive may be used for matching to a reference database or just the bit maps from 4, 5 and 6, 7 and 8, may be used. If the reference data set corresponds to the bit maps produced by 4, 5 and 6 then the system would provide a match irrespective as to whether the note was scanned in a direction parallel to one side of the note or at right angles.

The matching algorithm can include reference data matching to detect signals should the note have been scanned in the opposite direction i.e. from the direction of 6 to 4 rather than 4 to 6. The simplicity of the pattern means that the data storage requirements are minimal and also should the document be scanned at a skewed angle the computational requirements for different orientations are minimal.

The R, G and B data sample sets for the same area would provide bit maps in which no visible colour differentiation between the two inks was provided.

In this example the pixel size for the bit maps is shown diagrammatically as one or two. In practice this is likely to be too low a number because of edge effects which result from misregister between the print and scanned pixels: the diagram however represents the principle.

A device comprising areas may be placed in a variety of dispositions on a document. Examples of placings, which are not intended to be limiting, are shown in Figures 5 to 14 inclusive. Here device areas 2 are on documents 1: (the numbering of these is shown in Figure 5 but is omitted in Figures 6 to 14 for clarity).

Thus in Figure 5 one device 2 is shown in a central portion. In Figure 6 two devices are at opposite ends of a diagonal line of the document.

In Figure 7 the devices are disposed close to an edge. In Figure 8 devices are placed relatively centrally but close to each edge. In Figure 9 devices are placed in two orthogonal directions and in proximity of the edges of the document.

In Figure 10 the devices are placed in the vicinity of the corners. In Figure 11 the devices are placed approximately on a diagonal of the document. In Figure 12 two regularly spaced linear sets are provided, each set close to an edge.

In Figure 13 there is a random arrangement of devices. In Figure 14 each edge zone is protected with a less

regular arrangement of device areas than shown in Figures 8 and 11.

The devices may be the same or they may have different patterns. One side of a document or both sides may be protected, as for example in the case of a bank note which is a double side printed document. It is generally preferred that a multiplicity of devices be provided as this will tend to defeat any attempts to interfere with any one device. It may also allow each edge of a document to be protected so that copying is stopped before a significant proportion of the document has been copied (whether colour scanned or colour scanned and printed). It also helps to overcome problems of soiling by enabling the use of scoring techniques as described above.

It also allows the possibility of providing different anti-copy patterns so that certain copiers may reject some patterns but accept others, with other copiers rejecting both.

It is intended that the design elements should be relatively simple and possibly just geometric patterns or simple shapes such as alphanumeric characters or symbols.

Thus a linear series of markings will allow capture of the linear pattern if the document is linearly scanned in the linear marking direction. The software of the pattern matching system may not however allow recognition of the pattern if the document was scanned in the orthogonal direction.

Software routines could be provided to determine matching of the orthogonal pattern or an additional data set could be provided in which the pattern was held as an orthogonal pattern data set.

Similarly the pattern need not have linear symmetry and through software or data it should be possible to identify whether the pattern was scanned in an opposite direction.

The simple pattern of Figures 2-4 illustrates how this may be achieved. Other patterns are shown in Figures 15-24 which are not intended to be limiting but illustrative.

Figure 15 shows a series of regularly spaced squares. Both shape and distance apart may be used in determining a match.

Reference numerals are omitted from the remaining Figures for clarity each of which shows a device 2 formed by a background ink 3 and a pattern of an ink 4 having the same properties as described above.

Figure 16 shows a further series of squares. The whole pattern could be used for matching or simply three squares in a line. This reduces the amount of storage required but allows the device to be detected in whichever of the two orthogonal orientations it is presented. The shapes need not themselves be used for matching rather the transitions between absorbance and non-absorbance may be used in a sampled pixel line. Further examples of patterns are shown in Figures 17 and 18.

Sometimes documents may be presented for scanning at a skew angle and this may defeat some anti-copy device patterns. Although software orientation matching routines could be employed this may be too slow for some purposes. Here it may be possible to use a regular polygon such as a hexagon or indeed any multifaceted regular polygon having up to 16 sides. Thus the device may be readily detected when scanned in any direction parallel to any of the sixteen faces. As an alternative to providing an hexadecagon it would also be possible to provide a pair of octagons with one orientated by 18 degrees relative to the other so that taken as a pair one polygonal face will be presented in a direction which would correspond with a face of an hexadecagon.

In Figure 19 are two hexagons of different sizes so forming a two dimensional pattern and in Figure 20 two identical regular hexagons one having one pair of sides parallel to an edge of the document to be protected and the

other being rotated at an angle of 30 degrees relative to the other. In combination the pair of hexagons present all the facial orientations expected of a regular dodecagon.

Figure 21 represents a series of lines. Figure 22 has the letters "TDLR" which would normally be recognised by shape matching rather than a linear scan. Figure 23 shows a simple bar code and Figures 24 and 15 further geometrical patterns.

The copy prevention scanner could be incorporated in a colour copier which employs electrophotographic colour copying methods. Here the projected image of the document would be used for the RGB and invisible optical attribute detection.

The scanner may also be used with desktop publishing methods in which the scanned in image is converted from a bit map data set to an object orientated data set.

The devices of the invention may be incorporated in documents by printing a pair of inks which together would form the device, or the devices may be applied to a document or other flat surfaced printed article by applying a label which carries a device. For example devices could be affixed by hot stamping onto a document from a transfer film which exhibits the device.

Figure 26 illustrates schematically the general form of a colour copier. The document to be copied is supplied to a conveyor 10 mounted about rollers 11 driven by a motor (not shown) which conveys the document past a visible light analyse head 12 and an infrared analyse head 13. The document is illuminated under visible light as it passes beneath the analyse head 12, the light being generated from a source 14. Light reflected by the document is received by a photodetector 15, there being one photodetector for each colour component (for example red, green and blue). The output signals from the photodetectors are fed to respective A/D convertors 16 where the signals are sampled and digitized to generate digital data defining the colour component content of each pixel of the document, this data

then being fed to an output device shown schematically at 17 for further processing and then for controlling the generation of a copy of the document.

As the document passes under the analyse head 13, it is irradiated by a source 18 with infrared radiation, any reflected infrared radiation being detected by an infrared detector 19 whose output signal is fed to an A/D convertor 20. The digitized output signal is then fed to a controller 21 formed by a suitable programmed microprocessor. The visible, digital pixel information is also fed to the controller 21.

The controller 21 is connected to a store 22 which stores binary data defining one or more predetermined patterns which are indicative of a document which is not to be copied. In this example, we will refer to a copier which responds to the pattern shown in Figure 16. Figure 26 illustrates two alternative ways in which this pattern can be stored. The first method is shown at 23. In this approach, the pattern of pixels is stored in binary form. Thus, it is assumed that the ink 3 is absorbing and will define an area which is not sensed by the detector 19 and thus be coded with a binary "0". The ink 4 is not absorbing and so infrared radiation will be reflected and detected by the detector 19 and a binary "1" will be stored.

In use, the controller 21 will sense the incoming digital data defining the infrared response of the document and this will be in the form of a binary stream determined in accordance with whether successive pixels absorb or do not absorb infrared radiation. This binary stream is then stored in a memory within the controller (not shown) and subsequently the fully stored pattern is then compared with the pattern 23. If a match is found and the controller 21 determines that this match occurs in an area of the document which is substantially plain under visible radiation as indicated by the signals which the controller 21 receives from the analyse head 12 then this indicates

that copying should be inhibited and a suitable output signal is fed to the output device 17 to prevent any or any further output of the copy.

An alternative approach for storing the standard pattern is shown at 24. Since the copy protection device shown in Figure 16 will present to a single linear scan a similar appearance in each of two orthogonal directions, this appearance can be stored just once as shown at 24. The controller 21 then compares the detected pattern with the stored pattern 24 and if a match is found this is indicative that the copy protection device is present (providing the area also presents a substantially plain colour under visible illumination).

If the document is slightly soiled then it is possible that some parts of the device 2 will be obscured. This could mean that the infrared response will not be identical to the stored, expected response. In this situation, the controller 21 may allow a degree of tolerance so that, for example, if one of the binary 0's expected is in fact coded as a binary "1" this will still be accepted as a match. In some examples, if there is more than one difference between the detected pattern and the expected pattern then the controller 21 may not accept that there is a match. However, other comparisons may be made with other security features on the document. For example, these may include considering the position of the possible copy protection device on the document, considering whether other copy protection devices are present (even if these also do not satisfy individually the full match condition), or considering the presence of other security features such as magnetic threads, security indicia and the like. If these other conditions together indicate the likelihood that this is a document which should not be copied then a suitable copy inhibiting signal will be supplied to the output device 17.

CLAIMS

1. A document carrying indicia and at least one copy protection device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

2. A document according to claim 1, wherein the inks of the marking or one of the markings respond differently when viewed under infrared light.

3. A document according to claim 1 or claim 2, wherein the inks of the marking or one of the markings respond differently when viewed under ultraviolet light.

4. A document according to any of claims 1 to 3, wherein at least one of the inks of the marking or one of the markings absorbs said at least one wavelength outside the visible wavelength range to a different extent from the other ink.

5. A document according to any of claims 1 to 3, wherein at least one of the inks of the marking or one of the markings exhibits luminescence when viewed at and/or when illuminated under said at least one wavelength outside the visible wavelength range, the luminescence being different from that, if any, exhibited by the other ink.

6. A document according to any of the preceding claims, where the pair of inks of the marking or one of the markings are printed side by side.

7. A document according to any of the preceding claims, wherein the marking or one of the markings is lithographically printed.

8. A document according to any of the preceding claims, wherein the device or one of the devices has an area less than $2mm^2$.

9. A document according to claim 8, wherein the area of the device or one of the devices is less than 0.75 mm^2, preferably less than $0.2mm^2$.

10. A document according to any of the preceding claims, wherein the pattern comprises a geometric shape.

11. A document according to any of the preceding claims, wherein the or one of the copy protection devices is provided at a margin of the document.

12. A document according to any of the preceding claims, wherein the or at least one of the copy protection devices is provided in an area of the document which has been printed in a similar, visual colour to the device.

13. A document according to any of the preceding claims, the document carrying a plurality of said copy protection devices separate from said indicia.

14. A document according to claim 13, wherein two or more of the copy protection devices present different visual colours.

15. A document according to any of the preceding claims, wherein the document is a security document selected from printed currency including bank notes, traveller's cheques, bank cheques, vouchers, financial tokens, tickets, passports, passbooks, licences, share certificates, bonds, letters of credit, legal documents, certificates of authenticity or regulatory compliance, brand protection labels, excise seals, identity cards, passes permits, travel tickets, entrance tickets, lottery tickets, bingo tickets, and financial transaction cards.

16. A method of copy protecting a document carrying indicia, the method comprising applying to the document at least one marking separate from the indicia and defined by

a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

17. A method according to claim 16, wherein the inks of the marking or one of the markings respond differently when viewed under infrared light.

18. A method according to claim 16 or claim 17, wherein the inks of the marking or one of the markings respond differently when viewed under ultraviolet light.

19. A method according to any of claims 16 to 18, wherein at least one of the inks of the marking or one of the markings absorbs said at least one wavelength outside the visible wavelength range to a different extent from the other ink.

20. A method according to any of claims 16 to 18, wherein at least one of the inks of the marking or one of the markings exhibits luminescence when viewed at and/or when illuminated under said at least one wavelength outside the visible wavelength range, the luminescence being different from that, if any, exhibited by the other ink.

21. A method according to any of claims 16 to 20, where the pair of inks of the marking or one of the markings are printed side by side.

22. A method according to any of claims 16 to 21, wherein the marking or one of the markings is lithographically printed.

23. A method according to any of claims 16 to 22, wherein the device or one of the devices have an area less than $2mm^2$.

24. A method according to claim 23, wherein the area of the device or one of the devices is less than 0.75 mm^2, preferably less than 0.2mm^2.

25. A method according to any of claims 16 to 24, wherein the pattern comprises a geometric shape.

26. A method according to any of claims 16 to 25, wherein the or one of the copy protection devices is provided at a margin of the document.

27. A method according to any of claims 16 to 26, wherein the or one of the copy protection devices is provided in an area of the document which has been printed in a similar, visual colour to the device.

28. A method according to any of claims 16 to 27, comprising providing a plurality of said copy protection devices separate from said indicia on said document.

29. A method of copying a document comprising scanning the document under visible light to generate digital data defining one or more colour separations which together define the appearance of the document; and generating a copy of the document by controlling output means in accordance with the digital data, characterised by additionally scanning the document under at least one wavelength outside the visible wavelength range; monitoring the response of the document when scanned at said at least one wavelength and comparing the monitored response with one or more predetermined responses; and preventing the generation of a copy of the document if the result of the comparison indicates the presence of one or a predetermined number of copy protection devices, the or each device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern

is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

30. A method according to claim 29, wherein a copy of the document is not produced if the result of the scanning step indicates the presence of a plurality of said copy protection devices.

31. A method according to claim 30, wherein the document is not copied if a predetermined minimum number of said copy protection devices is detected each of which satisfies predetermined conditions.

32. Apparatus for copying a document, the apparatus comprising scanning means for scanning a document under visible light to generate digital data defining one or more colour separations representing the appearance of the document; and output means for generating a copy of the document in accordance with the digital data characterised by control means for causing a document to be copied to be illuminated under at least one wavelength outside the visible wavelength range; and detection means for detecting the response of the document to said illumination, the control means being responsive to the detection means to prevent the output means from generating a copy of the document if the detected response indicates the presence of one or a predetermined number of copy protection devices, the or each device comprising a marking separate from the indicia and defined by a pair of inks which present a continuous, substantially plain coloured area when viewed and illuminated under visible light, the presence of the different inks being substantially undetectable when the area is subjected to visible colour separation scanning, and wherein when the area is scanned at and/or illuminated under at least one wavelength outside the visible wavelength range a pattern is generated which is detectable, whereby the presence of this combination of properties indicates that a copying process should not be carried out.

33. Apparatus according to claim 32, wherein the control means includes a store for storing data defining the appearance of the or each copy protection device, and means for comparing information from the detection means with the stored patterns to determine whether the detected response corresponds to the or one of the stored patterns.

Fig.1.

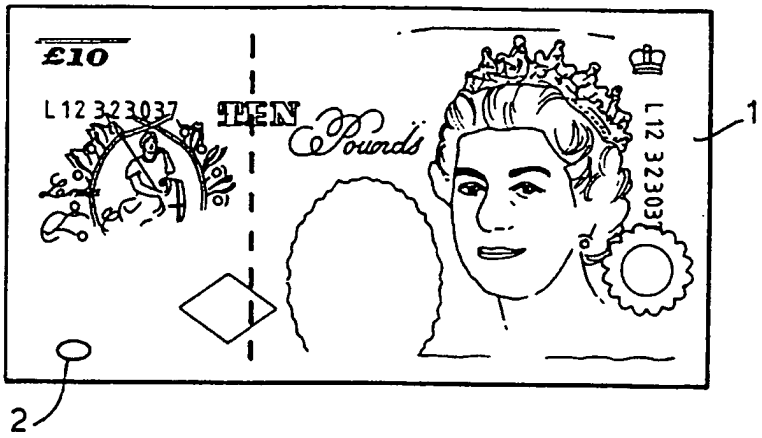


Fig.2.

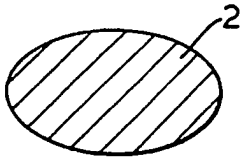


Fig.3.

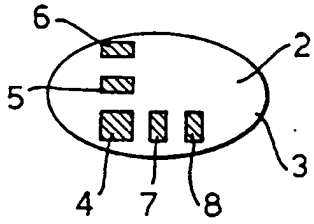


Fig.4.

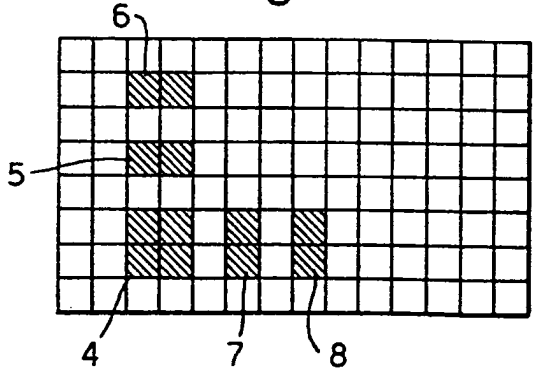


Fig.5.

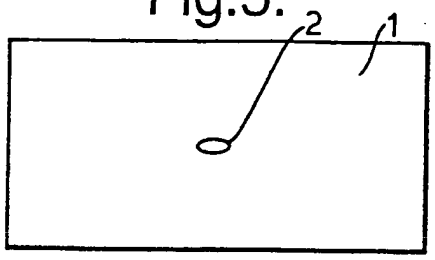


Fig.6.

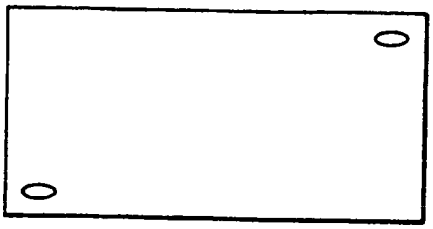


Fig.7.

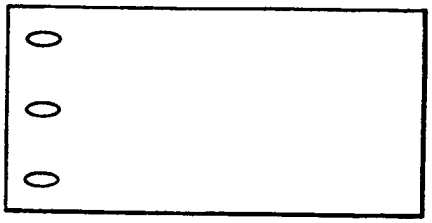


Fig.8.

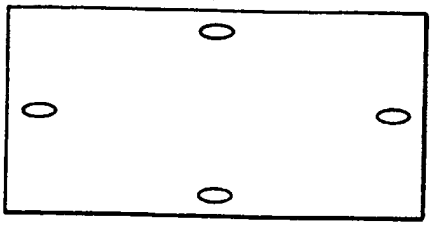


Fig.9.

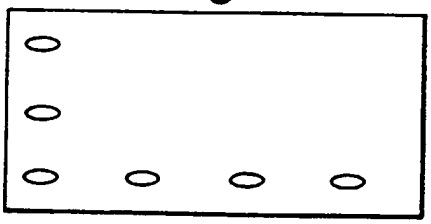


Fig.10.

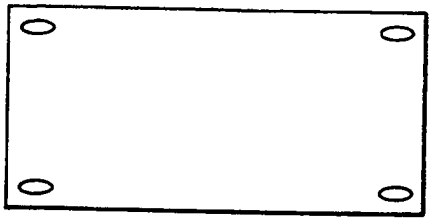


Fig.11.

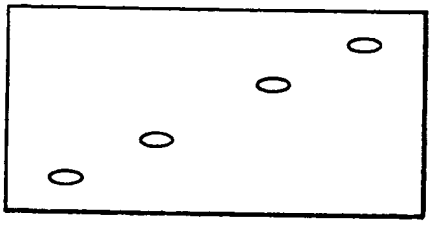


Fig.12.

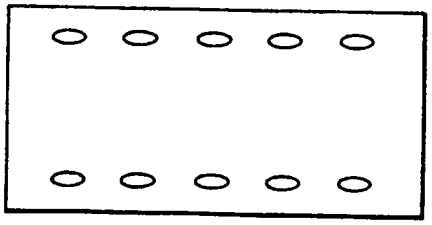


Fig.13.

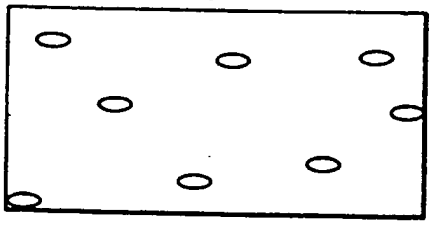


Fig.14.

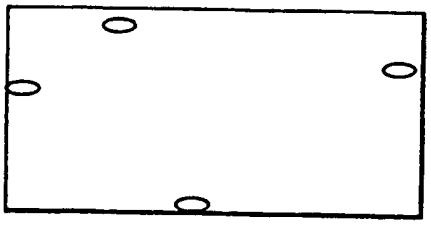


Fig.15.

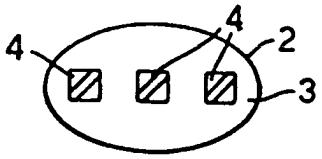


Fig.16.

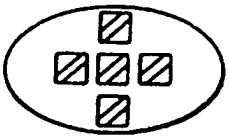


Fig.17.

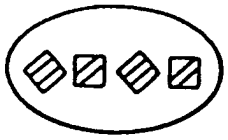


Fig.18.

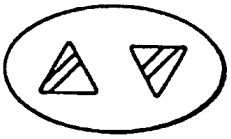


Fig.19.

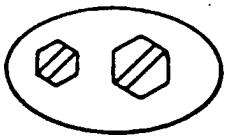


Fig.20.

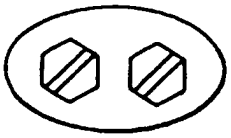


Fig.21.

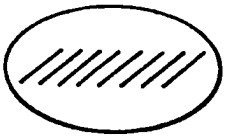


Fig.22.

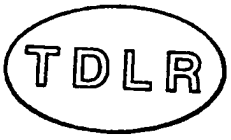


Fig.23.

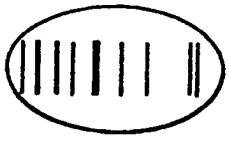
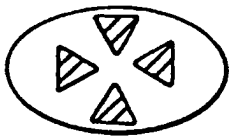


Fig.24.



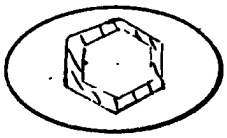
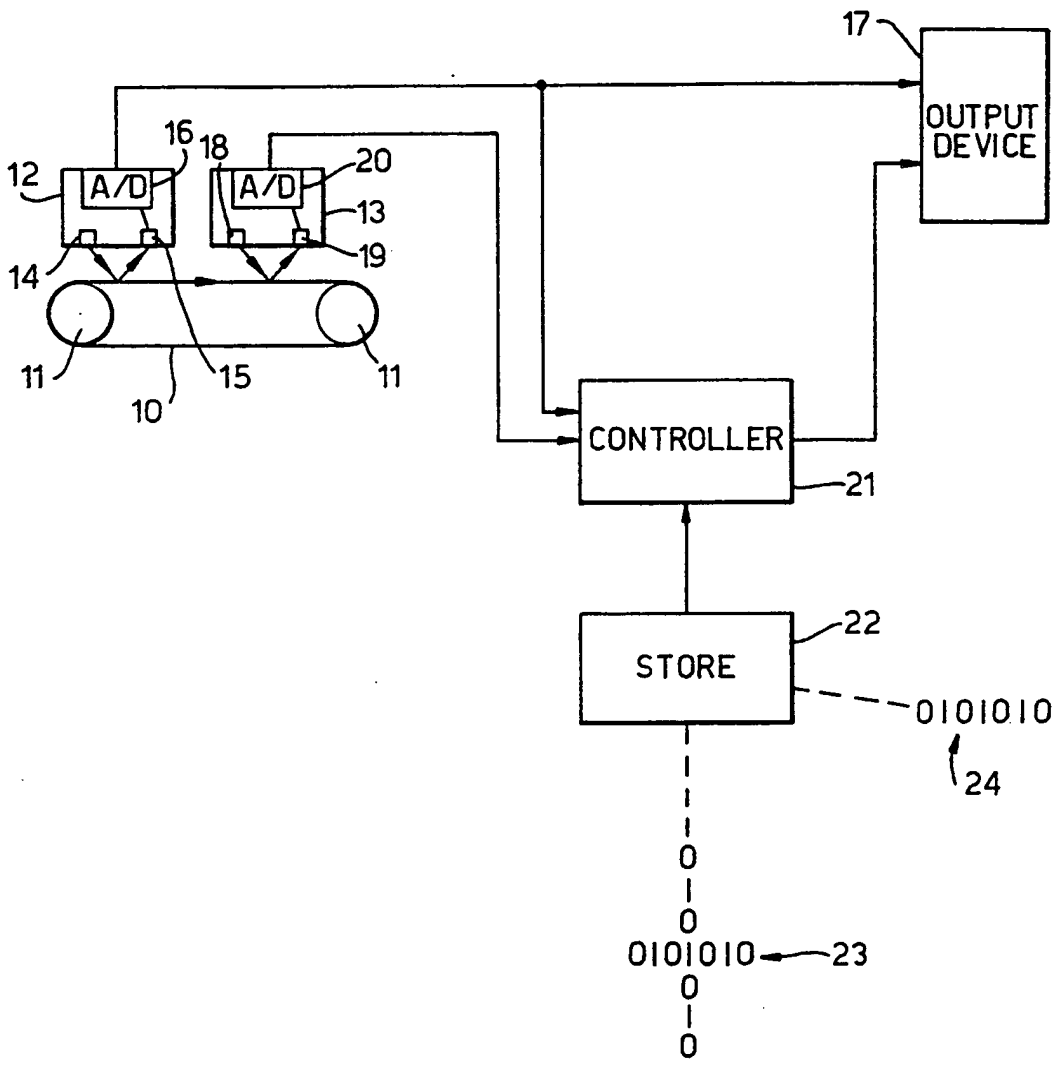


FIG 25

Fig.26.


17
OUTPUT DEVICE
16
18
12
A/D
A/D
20
13
19
14
11
10
15
11
CONTROLLER
21
22
STORE
0101010
24
0
0
0101010
23
0
0